

# CHAPTER 1

## INTRODUCTION

Tenaga Nasional Berhad (TNB) is the largest electricity utility company in Malaysia with an estimate of RM 71.4 billion worth in assets. The company is listed on the main board of Bursa Malaysia and employs approximately 28,000 staff to serve a customer base of over seven million in Peninsula Malaysia and Sabah ( TNB, 2010 ).

TNB's core business comprises of generation, transmission and distribution of electricity. With a total installed generation capacity of 12,000 MW ( including Sabah Electricity Sdn. Bhd. and Kapar Energy Ventures ), TNB is trusted for delivering reliable and efficient products and services. In Peninsula Malaysia, TNB contributes to 55 percent of the total industry capacity through six thermal stations and three major hydroelectric schemes ( TNB, 2010 ).

The energy sector plays a key role in the development and growth of our economy as the availability of adequate supplies of energy is a prerequisite to generate economic activities. In order to contribute towards sustaining and improving the competitive edge of the nation, the energy supply support system and services will continually be upgraded in terms of quality, reliability and efficiency; the 30% strategic reserve margin of electricity supply will have to be maintained. By mid 2000, the system's generation capacity had to be increased to 14,000MW (DEIA,1997).

Electricity demand for Peninsular Malaysia indicates a phenomenal growth rate due to

rapid demand from the industrial, commercial and domestic sectors. In order to meet the nation's electricity demand in the next millenium, the Malaysian Government has invited Tenaga Nasional Berhad to develop a coal fired power station project in the District of Manjung, in Perak Darul Ridzuan ( DEIA,1997).

TNB Janamanjung Sdn. Bhd. (TNBJ) is a wholly owned subsidiary of TNB, incorporated with the main objective to undertake this development, adopting an approach similar to the Independent Power Producer (IPPs). The power station will be based on three (3) units of 700MW with the first unit coming into commercial operations end of the year 2000. The power station will utilise proven pulverised coal combustion power station technologies firing mainly sub-bituminous coal with light oil for start-up operation (DEIA,1997).

### **1.1 Factors That Determined Selection of Coal Fired Power Station**

Under the Malaysian Government four fuel policy, the primary energy sources for power generation would be diversified into oil, gas, hydro and coal, with less dependence on oil (DEIA,1997).

Currently, the fuel diversification policies state coal, natural gas, oil, hydropower and renewable energy as national energy sources ( STAR,2009).

Proven world coal reserves are estimated to be 1.039 trillion tonnes, about five times

larger than oil or gas reserves, and may provide secured and cheap fuel supply for over 220 years ( DEIA,1997 ).

Well established and proven clean coal combustion technologies such as Pulverised Fuel Firing (PFF), Fluidised Bed Combustion (PBC) and Integrated Gassification Combined Cycle (IGCC) with advanced flue gas cleaning system for pollution control are available at reasonable cost. However, for a proven large scale power producer, a pulverised fuel firing technology is recommended for the 3 x 700 MW power station in Manjung. The largest IGCC plant being operated is only a 250 MW power station in Buggenum and 300 MW for circulating fluidised bed combustion technology (DEIA,1997).

Coal is an inhomogeneous organic fuel, formed largely from partially decomposed and metamorphosed plant materials under extremely high pressures and temperatures. It varies greatly in composition. Typical composition (mass percentage) includes carbon in the range of 65-95%, 2-7% hydrogen, up to 25% oxygen, up to 10% sulphur and 1-2% nitrogen. Inorganic matter (ash: Al, Ca, Cl, Fe, K, Mg, Na, P, S, Si and Ti) as high as 50% has been observed though 5-15% is typical. Moisture levels commonly vary from 2 to 20% but much higher values had been observed. Basically, coal is categorised into four types based on its physical and chemical compositions: lignite, sub-bituminous, bituminous and anthracite ( DEIA,1997 ).

## **1.2 Main Wastewater Treatment Plant**

Operation of coal fired power station generates wastewater. The wastewater can contain suspended matter and heavy metals coming from the coal used and the wastewater must be treated to meet requirements of environmental regulation before it can be discharged. For this purpose a main wastewater treatment plant has been incorporated as an auxiliary.

The sources of wastewater are:

- a) Effluent from Ash Pond
- b) Effluent from Station Air Heater Wash Water Sump and Ash Conditioning Water Storage Sump
- c) Effluent from Water Pretreatment Plant
- d) Effluents from Storm Water Basin Pumping Station
- e) Wash water from backwashing of sand filters via Backwash Waste Pump in the Waste Water Treatment Plant (Return from Waste Water Treatment Plant)
- f) Supernatant from Sludge Thickening Tank via gravity flow in the Waste Water Treatment Plant (Return from Waste Water Treatment Plant)
- g) Filtrate from Belt Press dewatering in the Filtrate Sump via Filtrate Pump in the Waste Water Treatment Plant (Return from Waste Water Treatment Plant) (TNBJ, 2003) .

Wastewater from above source is pumped into a primary wastewater holding pond.

Figure 1.1 shows a general view of the primary wastewater holding pond. Figure 1.2 shows process flow of Main Wastewater Treatment Plant (MWWTP).



Figure 1.1 – View of the Primary Wastewater Holding Pond

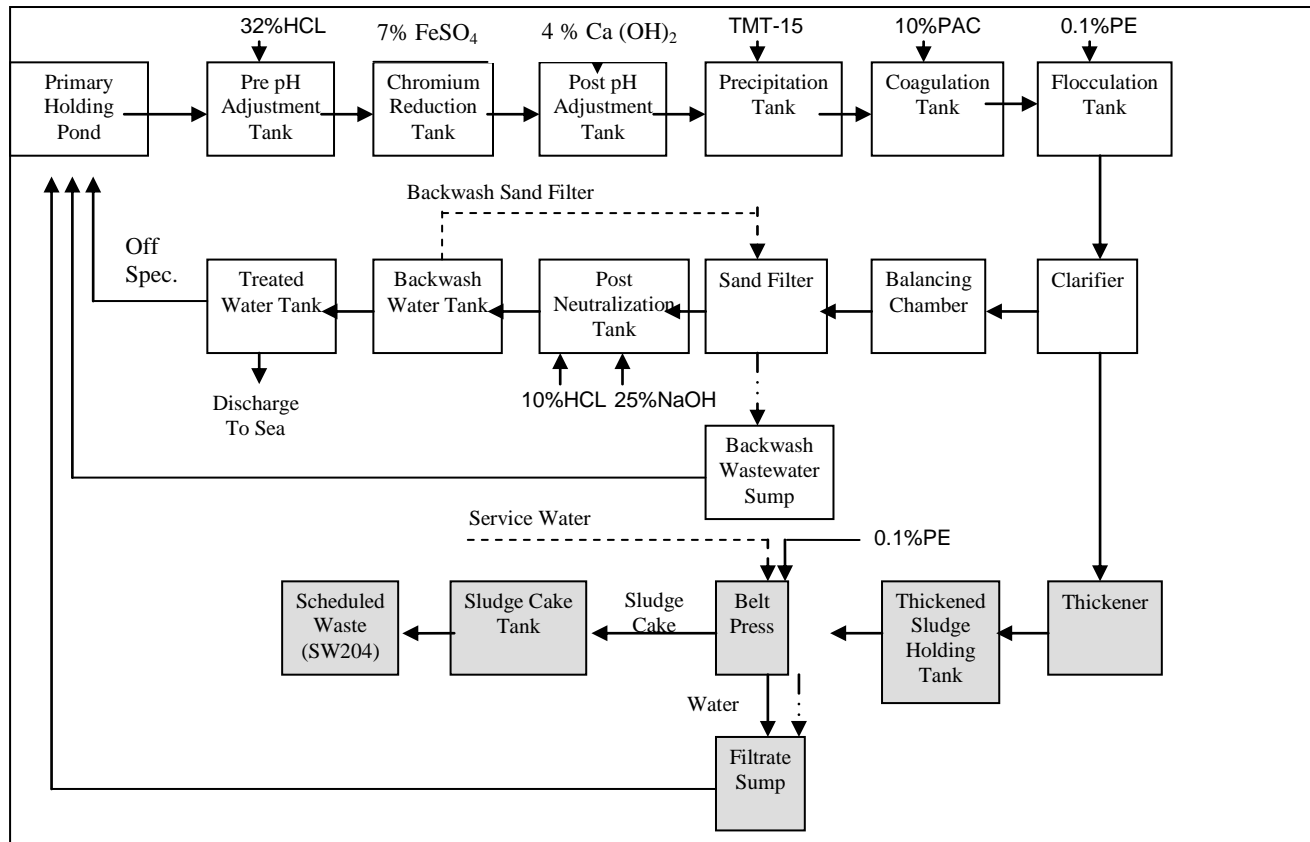


Figure 1.2 – Diagram showing process flow of Main Wastewater Treatment Plant

Source : TNBJ, 2003

Hydrochloric acid (HCl) and/or sodium hydroxide (NaOH) are added in the Primary Wastewater Holding Pond to adjust the pH to a range of about pH 6. Design flow rate of influents of waste into the Primary Wastewater Holding Pond from various external sources (excluding returns from the MWWTP) is 2201 cubic meter per day. Design flow rate of returns from the MWWTP is 336 cubic meter per day. Therefore total flow rate into the Main Waste Water Treatment Plant from the Primary Wastewater Holding Pond is 2537 cubic meter per day (TNBJ, 2003).

The wastewater treatment system comprises of precipitation, clarification, filtration processes and sludge dewatering facilities. The wastewater from the identified source is stored in a Primary Waste Water Holding Pond and pumped via Wastewater Transfer Pump through the Pretreatment Reaction Tank for pH adjustment and precipitation of metal hydroxide. A by-pass line is provided for the discharge of the Wastewater Transfer Pump for emergency where, wastewater could be recirculated into the Primary Wastewater Holding Pond (TNBJ, 2003).

Wastewater from the Primary Wastewater Holding Pond is pumped into the pre pH adjustment tank where pH is adjusted to about 3 for the chromium reduction process. From the Pre pH Adjustment Tank the wastewater overflows into the Chromium Reduction Tank where ferrous sulphate ( $\text{FeSO}_4$ ) is added to reduce chromium hexavalent to chromium trivalent. This wastewater then flows into the Post pH Adjustment Tank where Lime is then added to increase the pH to about pH 9 - 10 for precipitation of metals (TNBJ, 2003).

From the Post pH Adjustment Tank, wastewater overflows into the Precipitation Tank, where either sodium sulphide ( $\text{Na}_2\text{S}$ ) or TMT 15 is dosed (if required) to further precipitate heavy metals, such as Arsenic and Silver. TMT 15 will be used in normal condition (where the presence of arsenic is not excessive) since TMT 15 is easier for handling compared to the safety hazard associated with sodium sulphide. Sodium sulphide will only be used when the arsenic is present in the incoming wastewater (TNBJ, 2003). TMT 15 ( trimercapto-S-triazine) is a proprietary chemical (Mcilvaine company, 2006).

Wastewater then overflows into the Coagulation Tank and Flocculation Tank, where polyaluminium chloride (PAC) and polymer are dosed respectively to enhance the coagulation and flocculation processes. Mixing devices are provided in all the Pretreatment Reaction Tanks to facilitate proper mixing of chemicals to the wastewater for the reactions. From the Coagulation Tank and Flocculation Tank, wastewater gravitates into two duty Clarifiers. The surface area of each clarifier is around  $38 \text{ m}^2$ . Each Clarifier can be isolated by using manual butterfly valve. A sludge level detector on a stand pipe is installed to detect the sludge level in the clarifier for desludge operation. A rotating Clarifier Scraper in each Clarifier scrapes the settled sludge to the center of the clarifier for draw off by pumps. The Clarifier Scrapers are central motor driven on a fixed bridge. Sludge in the center of the Clarifiers is pumped by the Sludge Transfer Pumps. The periodical removal of sludge from the Clarifiers is by a timed extraction cycle or by level using the sludge level detector (selectable) (TNBJ, 2003). Figure 1.3 shows a general view of the two clarifiers.





Figure 1.3 – View of Two Clarifiers

The clarified water from the Clarifiers overflow into a Distribution Tank before distributing into three units of dual media Sand Filters, where any carried over solids are removed. The dual media Sand Filters contain a coarse layer of anthracite, one layer of filtering fine sand and also a layer of coarse sand. The filtered water then gravitates into the Post Neutralization Tank (TNBJ, 2003).

The filtered water is then discharged into the Post Neutralization Tank. Hydrochloric acid (HCl) or caustic (NaOH) is dosed (if required) to adjust the pH of filtered water

to about pH 6.0 to pH 8.5. (Preset pH value is pH 7). This Post Neutralization Tank is equipped with the Post Neutralization Agitator to mix the content (TNBJ, 2003).

The Sludge Treatment Plant is designed to dewater sludge from the Wastewater Treatment Plant to a solid form for land disposal. Waste sludge from Clarifiers is pumped periodically to the Thickener, on a timed basis or based on sludge level, for thickening to about 4% solid content. Polymer (Anionic Polyelectrolyte) is dosed to condition the sludge. The thickened sludge of about 4% concentration Thickener is then transferred to Thickened Sludge Tank (TNBJ, 2003).

Thickened sludge is then pumped by Belt Press Feed Pumps to the Belt Press for dewatering to about 25% solid content. Polymer (Anionic Polyelectrolyte) is dosed to condition the sludge for watering (TNBJ, 2003).

### **1.3 Problem Statement**

The MWWTP is automated with Programmable Logic Controller (PLC). Chemical dosing is done through various dosing pumps where the dosing rate is set manually. One of the problems encountered during the operation of the MWWTP is the handling of hydrated lime.

The 25kg hydrated lime bags have to be emptied into a bag unloader manually. Figure 1.4 shows the bag unloaders. From here it is transferred into a silo using compressed air. Hydrated lime from the silo is automatically transferred, using a screw conveyor, into the measuring tank where measured quantity is taken. Then the measured quantity of lime is added into the dosing tank and the required strength of lime solution is prepared. The prepared lime solution is dosed into the post pH adjustment tank by dosing pump.



Figure 1.4 – View of bag unloaders for Hydrated Lime, Ferrous Sulphate and Sodium Sulphite

While unloading the hydrated lime into the bag unloader some of it spills and some gets airborne. During this activity the area around the bag unloader gets messy. Personnel handling the chemical need to wear personal protective equipment (PPE) and lime being alkaline causes itchiness when there is inadvertent contact with skin.

#### **1.4 Aim and Objective of the Study**

The aim of the study is to explore the use of alternative chemicals to replace hydrated lime in waste water treatment plant of Sultan Azlan Shah Power Station to achieve easy chemical handling and waste minimization.

The objectives shall be :

- 1) To compare effectiveness of alternative chemicals selected to replace the existing chemical for treatment of effluent in the waste water treatment plant in coal fired power generation.
- 2) To identify the areas for waste minimisation and cost effectiveness in using the alternative chemicals.

#### **1.5 Significance of Study**

The expected outcome of the laboratory scale study will indicate which alternative chemical will work effectively and be a feasible substitute to hydrated lime.

Waste minimisation and cost effectiveness in using the alternative chemical shall be analysed.

## **1.6 Limitations of Study**

This study requires the determination of settling time and floc size which requires some amount of visual judgement. The settling time was taken to the nearest minute when most of the big flocs have settled to the bottom of the beaker. There can be an error of  $\pm 1$  minute. For floc size, the chart attached as appendix 2 was used and there can also be an error of  $\pm 1$  size.

In this study the supernatant solution after flocculation and settling was analysed for 11 parameters namely pH, Chemical Oxygen Demand, Suspended Solids, Chromium Hexavalent, Copper, Manganese, Zinc, Boron, Iron, Oil & Grease, Turbidity. This was because for this study the existing facility available at Sultan Azlan Shah Power Station's laboratory for wastes water monitoring was used. The above mentioned parameters are the ones identified and tested for monitoring of wastewater quality at Sultan Azlan Shah Power Station. This is also a limitation of this study as the full analysis of 23 parameters stated in Environmental Quality (Sewage and Industrial Effluents) Regulations 1979 (EQSIER 1979) standard B would have been a better indication. However based on the findings of this preliminary study, tests were carried out in the plant using sodium hydroxide for pH adjustment and the treated water was tested for the 23 parameters. The results were found to be within EQSIER 1979 standard B limits and are shown in Table 5.2.